

(19) 日本国特許庁 (JP)

(12) 公開特許公報 (A)

(II) 特許出願公開番号

特開平8-48510

(43) 公開日 平成8年(1996)2月20日

(51) Int.Cl.  
C 01 B 31/02  
// H 05 H 1/50

識別記号 101 Z  
府内整理番号 9216-2G

F I

技術表示箇所

審査請求 未請求 請求項の数2 OL (全7頁)

(21) 出願番号 特願平6-183266

(22) 出願日 平成6年(1994)8月4日

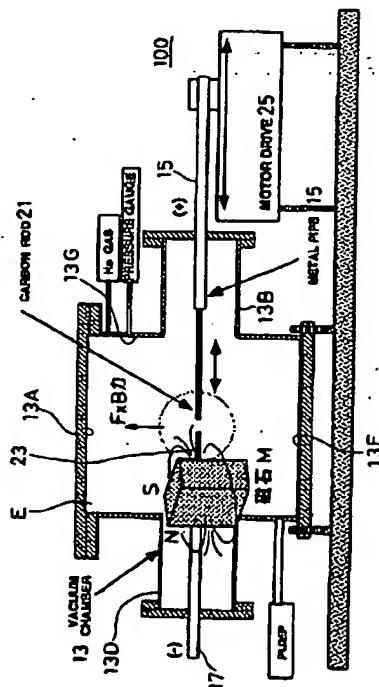
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(54) 【発明の名称】 アーク放電によるフラーレン自動合成装置

(57) 【要約】

【目的】 磁場による  $J \times B$  力によりアーク炎部のプラズマをジェット放出させてマイナス側の炭素電極棒への炭素再付着量を抑制することで、フラーレン生成質量を増加させた新規なフラーレン自動合成装置を提供する。

【構成】 真空チャンバー13内にヘリウムガスを充填するとともに、プラス・マイナス一対の炭素電極棒21、23を対向配置し、両炭素電極棒間にアーク炎を発生させる。更に、プラス側炭素電極棒21からマイナス側炭素電極棒23に流れる電流と直交方向に定常磁束密度(磁場)Bを付与する磁場付与手段M、Eを配置する。これにより、上記アーク炎Aに対して垂直上方にプラズマのジェット放出を引き起こす  $J \times B$  力を付与させたアーク放電によるフラーレン自動合成装置である。



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## 【特許請求の範囲】

【請求項1】 真空容器である真空チャンバー内に希ガスを充填するとともに、プラス・マイナス一対の炭素電極棒を対向配置し、上記両炭素電極棒間にアーク炎を発生させ、更にプラス側炭素電極棒からマイナス側炭素電極棒に流れる電流と直交方向に磁場を付与する磁場付与手段を配置し、上記アーク炎に対して垂直上方にプラズマのジェット放出を引き起こす  $J \times B$  力を付与させることを特徴とするアーク放電によるフラーレン自動合成装置。

【請求項2】 請求項1において、磁石又は電磁石によって磁場付与手段を構成したことを特徴とするアーク放電によるフラーレン自動合成装置。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】 本発明は、アーク放電によるフラーレン自動合成装置に関し、直流アーク放電によるフラーレン合成時に、マイナス側の炭素電極棒への炭素再付着を低下させ、より効率的なフラーレン合成が行えるよう改進したものである。

## 【0002】

【従来の技術】 煤に含有するフラーレンC<sub>60</sub>は、新しい形状の炭素分子からなり、電池材料、エレクトロニクス、触媒等に使用されている。上記フラーレンの効率的な合成方法として、直流アーク放電法がある。この具体的なフラーレン合成装置10は、図10に示すように、真空チャンバー1内に金属管3、5を対向配置し、この金属管3、5内に炭素棒7、9を通してその先端を所定の間隔に対向させる。

【0003】 そして、真空にしたチャンバー1内の空間Eにヘリウムガスを充填させた状態にて、直流電圧を両炭素電極棒7、9間にかけてアーク放電を起させ、図11のアーク炎Aを発生させる。このとき、プラス側の炭素電極棒7が加熱されて蒸発し、プラスの炭素イオンや炭素原子となり、チャンバー1内での熱対流により上方へ吹き上げられ、空中で炭素原子同士が化学反応を起してフラーレンC<sub>60</sub>という炭素分子が生成され、これは煤としてチャンバー1の上部壁1Aに多く付着する。プラス側の炭素電極棒7が加熱蒸発して、マイナス側の炭素電極棒9との隙間が大きくならないように、モータドライブの送り制御手段11により、プラス側の炭素電極棒7をマイナス側の炭素電極棒9の方へ送り出している。

## 【0004】

【発明が解決しようとする課題】 上記直流アーク放電によるフラーレン合成装置10によると、図11に示すように、両電極の空間は球形の「アーク炎A」で全体的に覆われる。そして、アーク中炭素イオンはマイナス側へ加速されていく。従って、プラス側の炭素電極棒7から加熱蒸発した炭素原子がマイナス側の炭素電極棒9に積極的に再付着するため、フラーレン合成率の低下、放電

条件制御が難しくなる。マイナス側の炭素電極棒9の成長による連続放電の困難化等の障害が生じる。このために、一定時間毎にマイナス側炭素電極棒9の析出物除去作業が必要になり、フラーレンC<sub>60</sub>の合成率を大きく低下してしまうという問題点がある。

【0005】 本発明は、上記従来の直流アーク放電によるフラーレン自動合成装置における問題点を解消するために、磁場による  $J \times B$  力によりアーク炎部のプラズマをジェット放出させてマイナス側の炭素電極棒への炭素再付着量を抑制することで、フラーレン生成質量を増加させた新規なフラーレン自動合成装置を提供することを目的とする。

## 【0006】

【課題を解決するための手段】 上記目的を達成するべく、請求項1の発明は、真空容器である真空チャンバー内に希ガス（ヘリウムガス、アルゴンガス等）を充填するとともに、プラス・マイナス一対の炭素電極棒を対向配置し、上記両炭素電極棒間にアーク炎を発生させ、更にプラス側炭素電極棒からマイナス側炭素電極棒に流れる電流と直交方向に磁場（定常磁束密度）を付与する磁場付与手段を配置し、上記アーク炎に対して垂直上方にプラズマのジェット放出を引き起こす  $J \times B$  力（ローレンツ力）を付与させることを特徴とするものである。

【0007】 又、請求項2の発明は、請求項1において、磁石又は電磁石によって磁場付与手段を構成したことを特徴とするものである。

## 【0008】

【作用】 上記請求項1の発明によると、電流と垂直方向に定常磁束密度が磁場により存在するから、アーク中電子、イオンは  $J \times B$  力により垂直上向に加速され、プラズマのジェット放出を引き起こす。雰囲気ガス圧力が高い条件では、この流れが熱対流速度を高め、蒸発炭素がマイナス側炭素電極棒に到達する前に、気中炭素を上方に吹き上げてしまう。よって、アーク炎の形状も上方へ尾を引いた形となる。

【0009】 上記作用により、蒸発炭素がマイナス側炭素電極棒への再付着を抑える働きの他、熱対流の加速や炭素流束を望んだ方向へ制御することも可能となり、更に等価的な放電抵抗を高め、炭素加熱効率の上昇も期待できる作用効果が得られる。

【0010】 本発明の請求項2によると、磁場付与手段を磁石又は電磁石によっているから、簡潔な構成にて  $J \times B$  力をアーク炎に対して発生させられる上に、磁束密度の調節による  $J \times B$  力の調節も電磁石によれば、簡潔に行える。

## 【0011】

【実施例】 次に、本発明に係る直流アーク放電のフラーレン自動合成装置の実施例につき、図面により具体的に説明する。図1、2は、本発明に係るアーク放電によるフラーレン自動合成装置100の第1実施例を示してい

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る。

【0012】上記フーラーレン自動合成装置100は、ステンレス製の真空容器（例えば、直径約18cm、高さ20cmで、水平面内の四方に枝管13B, 13C, 13D, 13Eを持つ）である真空チャンバー13内に金属管15, 17を対向配置し、この金属管15, 17内に各炭素電極棒21, 23を通してその先端を所定の間隔に対向させている。そして、10<sup>2</sup> Torr以下に排気したチャンバー13内の真空空間Eに、ヘリウムガスを約300 Torr充填させている。両炭素電極棒21, 23の接触による放電開始後も、図示しない直流電源からの直流電圧が付与され続ける。更に、直流の放電電流が常に一定になるように、放電ギャップ間がモータードライブである送り制御手段25により、プラス側の炭素電極棒21をマイナス側の炭素電極棒23の方へ送り出して制御されるよう構成されている。

【0013】図2に示すように、上記フーラーレン自動合成装置100の左前方（枝管13Eに接近した真空容器13の外壁部）には、磁石M（例えば7×4×4cmの直方体フェライト磁石）が配置され、この磁石Mにより磁場（アーケ部分の磁束密度は約23ガウス）が両電極21, 23間に直交した定常磁束密度Bとして矢印方向に与えられている。

【0014】しかして、上記両炭素電極棒21, 23間に、例えば、放電電流Id=50~100A、炭素棒直径d=6mm、放電時間Td=30分~1時間の条件の基で、直流電圧を掛けてアーケ放電を起させると、図5のアーケ炎A'を発生させる。上記アーケ炎A'は、電流Jと垂直方向に定常磁束密度Bが磁場により存在するから、アーケ中電子、イオンはJ×B力により垂直上方向に加速され、プラズマのジェット放出を引き起こした形状を呈する。

【0015】よって、雰囲気ガス圧力が高い条件では、この流れが熱対流速度を高め、蒸発炭素がマイナス側の炭素電極棒23に到達する前に、気中炭素を上方に吹き上げる。よって、アーケ炎A'の形状も上方へ尾を引いた形となる。このとき、プラス側の炭素電極棒21が加熱されて蒸発し、プラスの炭素イオンとなり、チャンバー13内の熱対流により上方へ吹き上げられ、空中で炭素原子同士が化学反応を起してフーラーレンC<sub>60</sub>という炭素分子が生成され、これは煤としてチャンバー13の上蓋内壁13Aに多く付着するよう作用する。

【0016】そして、放電終了後、フーラーレン自動合成装置100の上蓋13A内、側面13G、底面13Fの3カ所に付着した煤を集め、その重さを測定する。次にそれぞれの煤を良く搔き混ぜた後、その1mgを7mlのヘキサンで抽出し、吸光分析により煤中のフーラーレンC<sub>60</sub>の含有率を測定した各結果を次に示す各グラフで説明する。

【0017】先ず、図6はマイナス側の炭素電極棒23

に、再付着する炭素の質量W<sub>depo</sub>(g)を従来型の磁場なし(a)と、本発明の磁場あり(b)で比較したものである。磁場なし(a)の約4depo(g)に対して、磁場あり(b)は約2depo(g)となり、50%減少していることが分かる。又、図7に示すように、マイナス側の炭素軸方向の堆積長さL<sub>depo</sub>(mm)についての比較でも、磁場なし(c)の30depo(mm)から、磁場あり(d)の18depo(mm)に減少している。尚、この時の放電電流80A、ヘリウム圧力300 Torr、ギャップ長さ約4mm、放電時間1時間、ロッド間電圧31~35Vである。

【0018】次に、図8は真空容器13の上部13A、側面13G、底部13Fに堆積した煤質量を磁場ありと、磁場なしで比較している。上部13A、側面13Gにおいて、磁場により煤生成量が増えており、特に、上部は質量が2倍近くであり、炭素流束の制御の効果が現われている。一方、この時のプラス側炭素電極棒21の減少質量は、磁場ありの方が小さく、より効果的な煤発生が行われていることも分かった。

【0019】続いて、図9では、キシレン抽出した溶液の吸光度を比較している。即ち、λ=329nmのC<sub>60</sub>の吸光度(A B S)よりC<sub>60</sub>の含有率を比較すると、上部、側面、底部の何れの場所においても、磁場ありの方がフーラーレンの含有率が高いことが分かる。特に、上部13Aでの含有率は約15重量%となる効果が見られる。その他として、放電の等価抵抗は磁場により約1%上昇し、磁場強度に依存するが、まだその値は小さい。放電維持する最大ギャップ長も磁場により短くなっている。

【0020】本発明のフーラーレン自動合成装置100は、上記実施例に限定されずその詳細構成を設計変更できること勿論である。例えば、図3, 4に示す第2実施例のように、磁石Mに替えて、電磁コイルEMを枝管13Eに嵌合させた形態で備えたフーラーレン自動合成装置100としてもよい。その他は、第1実施例と同一構成である。この第2実施例においても、上記第1実施例のフーラーレン自動合成装置100と全く同様の作用効果が得られることが確認された。

【0021】この第2実施例による作用上の特徴は、磁束Bの方向が電極21, 23に対して完全に直交すること、そして、磁束密度の調節が電磁コイルEMの電流制御で自由自在に行えるから、アーケ炎A'即ち、F×B力の調節も自在に行えることである。

【0022】上記各実施例は、実験装置として製作し、且つそれから得られた結果であり、実際の工場で稼働されるときは、もっと大規模なものとし得る。また、プラス側炭素電極棒21の電極消耗に相応して電極間隔を一定に保つ送り制御手段25は、プラス側炭素電極棒21を移動させているが、マイナス側炭素電極棒23を移動させるようにしても良い。

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## 【0023】

【効果】以上詳述したように、請求項1の発明によるときは、電流と垂直方向に定常磁束密度が磁場により存在するから、アーク中電子、イオンは  $J \times B$  力により垂直上向に加速され、プラズマのジエット放出を引き起し、雰囲気ガス圧力が高い条件で、この流れが熱対流速度を高め、蒸発炭素がマイナス側電極に到達する前に、気中炭素を上方に吹き上げてアーク炎を上方へ尾を引いた形とする。これで、蒸発炭素がマイナス側の炭素電極への再付着を抑えられる効果を発揮する。

【0024】更に、熱対流の加速や炭素流束を望んだ方向へ制御することも可能となり、更に等価的な放電抵抗を高め、炭素加熱効率の上昇も期待できる等の多くの効果が得られる。

【0025】そして、請求項2の発明によるときは、磁場付与手段を磁石又は電磁石によっているから、簡潔な構成にて  $J \times B$  力をアーク炎に対して発生させられる上に、磁束密度の調節による  $J \times B$  力の調節も電磁コイルによると、簡潔に行えるという効果がある。

## 【図面の簡単な説明】

【図1】本発明の第1実施例を示す図で、フラーレン自動合成装置の正断面図である。

【図2】本発明の第1実施例を示す図で、フラーレン自動合成装置の平断面図である。

【図3】本発明の第2実施例を示す図で、フラーレン自動合成装置の正断面図である。

【図4】本発明の第2実施例を示す図で、フラーレン自動合成装置の平断面図である。

【図5】本発明の第1実施例を示す図で、アーク炎の斜視図である。

【図6】本発明の第1実施例を示す図で、再付着する炭

素質量の比較図である。

【図7】本発明の第1実施例を示す図で、炭素軸方向の堆積長さの比較図である。

【図8】本発明の第1実施例を示す図で、真空容器に堆積する煤質量の比較図である。

【図9】本発明の第1実施例を示す図で、真空容器に堆積する  $C_{60}$  含有率の比較図である。

【図10】従来型のフラーレン自動合成装置の平断面図である。

10 【図11】従来型のフラーレン自動合成装置のアーク炎を示す斜視図である。

## 【符号の説明】

13 真空容器（真空  
チャンバー）

13A 上蓋内壁（上  
部）

13B, 13C, 13D, 13E 枝管  
21 プラス側の炭素  
電極棒

23 マイナス側の炭  
素電極棒

A アーク炎

B 磁束密度

C<sub>60</sub> フラーレン

E M 電磁コイル（電  
磁石）

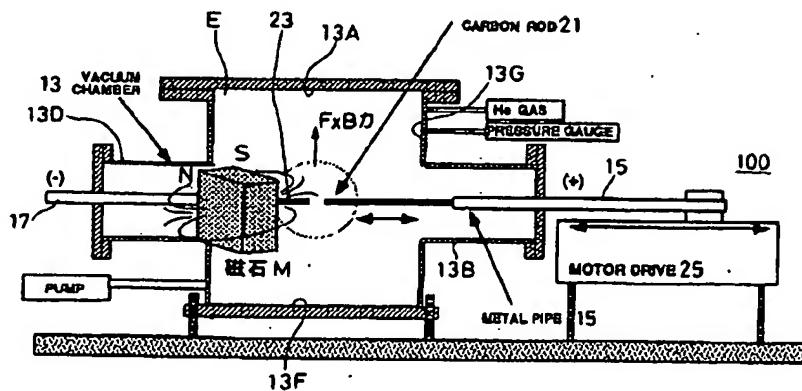
M 磁石

J 電流

$J \times B$  作用力

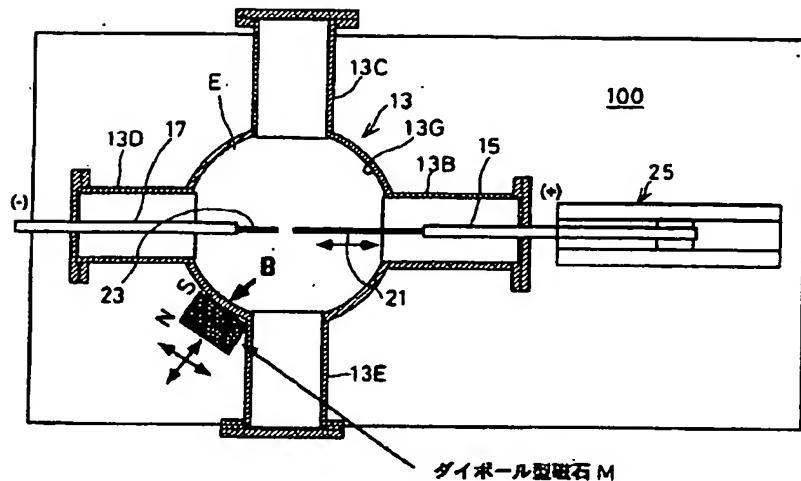
100, 100 フラーレン自動合成装置

【図1】

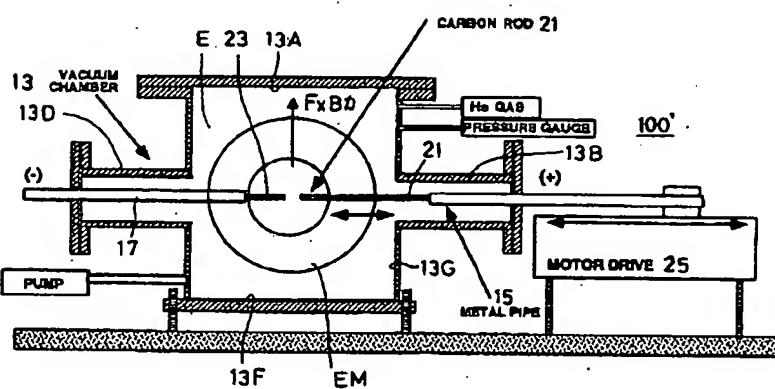


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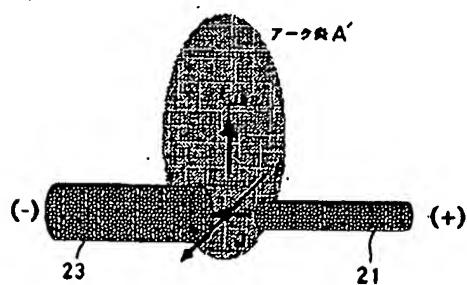
【図2】



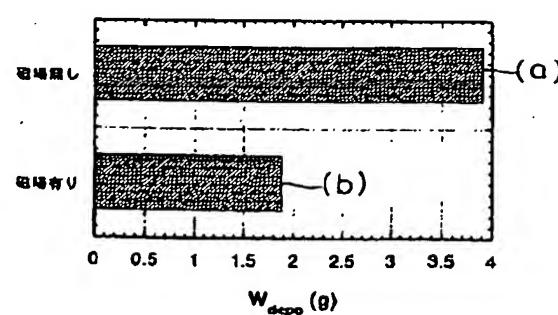
【図3】



【図5】

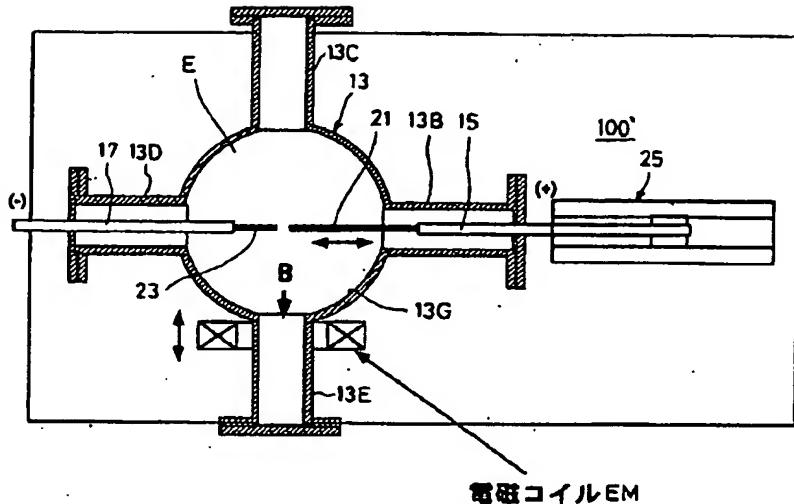


【図6】

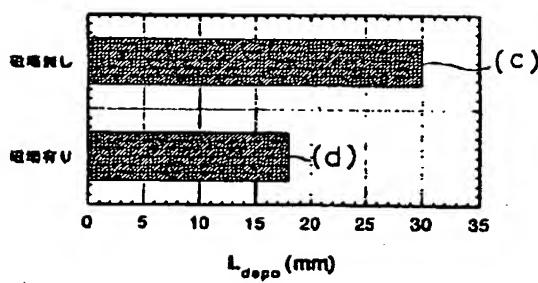


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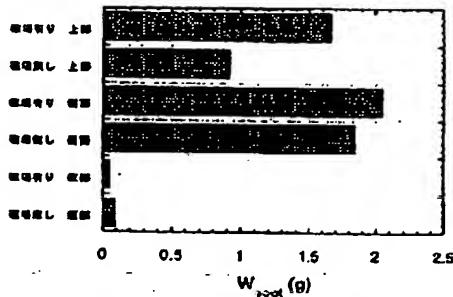
〔図4〕



[图 7]

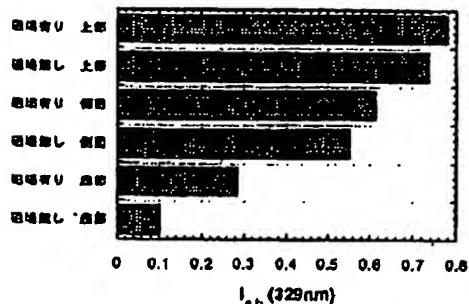


〔図8〕



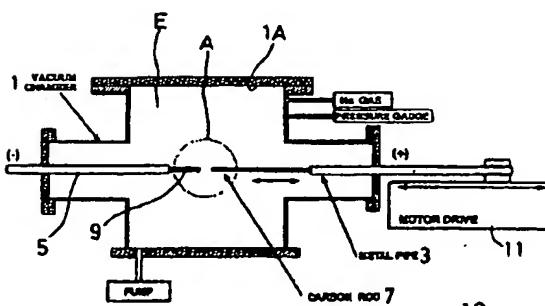
### 容器上部、側面、底部に堆積した 煤質量についての比較。

[ 9 ]



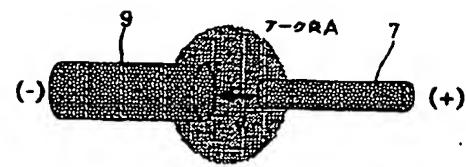
### 容器上部、側面、底部に堆積した 煤のC<sub>6</sub>含有率についての比較（キ シレン抽出した溶液の吸光度）。

〔四〕 10



(7)

【図11】



## PATENT ABSTRACTS OF JAPAN

(11)Publication number : 08-048510

(43)Date of publication of application : 20.02.1996

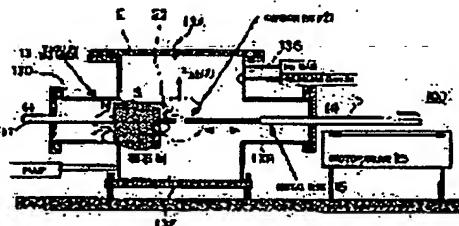
(51)Int.Cl. C01B 31/02  
// H05H 1/50(21)Application number : 06-183266 (71)Applicant : MIENO SATORU  
SANYO ALUM:KK

(22)Date of filing : 04.08.1994 (72)Inventor : MIENO SATORU

## (54) AUTOMATIC FULLERENE SYNTHESIZER BY ARC DISCHARGE

## (57)Abstract:

**PURPOSE:** To provide a novel automatic fullerene synthesizer which increases fullerene forming mass by jet releasing the plasma of an arc flame part with  $J \times B$  force generated by a magnetic field, and suppressing the readhesion of carbon on a carbon electrode rod on a minus side.



[Kind of final disposal of application other than  
the examiner's decision of rejection or  
application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's  
decision of rejection]

[Date of requesting appeal against examiner's  
decision of rejection]

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## DETAILED DESCRIPTION

---

### [Detailed Description of the Invention]

#### [0001]

[Industrial Application] About the fullerene automatic synthesizer unit by arc discharge, this invention reduces the carbon reattachment to the carbon electrode by the side of minus at the time of the fullerene composition by DC arc discharge, and it is improved so that more efficient fullerene composition can be performed.

#### [0002]

[Description of the Prior Art] The fullerene C60 contained for soot consists of a carbon-content child of a new configuration, and is used for a cell material, electronics, a catalyst, etc. There is a DC arc electric discharge method as the efficient synthetic method of the above-mentioned fullerene. This concrete fullerene synthesizer unit 10 carries out opposite arrangement of the metallic conduits 3 and 5 into the vacuum chamber 1, and makes that head counter a predetermined gap through carbon rods 7 and 9 in this metallic conduit 3 and 5, as shown in drawing 10.

[0003] And in the condition of having made the space E in the chamber 1 made into the vacuum filling up with gaseous helium, apply direct current voltage between both the carbon electrodes 7 and 9, arc discharge is made to cause, and arc flame A of drawing 11 is generated. At this time, the carbon electrode 7 by the side of plus is heated, and it evaporates, becomes the carbon ion and carbon atom of plus, and is pressured upwards upwards by the heat convection within a chamber 1, and carbon atoms cause a chemical reaction in the air, a carbon-content child called fullerene C60 is generated, and this adheres in up wall 1A of a chamber 1 mostly as soot. The carbon electrode 7 by the side of plus carried out heating evaporation, and the carbon electrode 7 by the side of plus is sent out to the direction of the carbon electrode 9 by the side of minus by the delivery control means 11 of a motor drive so that the crevice between the carbon electrodes 9 by the side of minus may not become large.

#### [0004]

[Problem(s) to be Solved by the Invention] According to the fullerene synthesizer unit 10 by the above-mentioned DC arc discharge, as shown in drawing 11, on the whole, the space of two electrodes is covered by globular form "arc flame A." And the carbon ion in an arc is accelerated to the minus side. Therefore, in order that the carbon atom which carried out heating evaporation from the carbon electrode 7 by the side of plus may carry out the reattachment to the carbon electrode 9 by the side of minus positively, decline in the rate of fullerene composition and a discharge conditional control become difficult. Failures, such as difficultizing of the continuous discharge by growth of the carbon electrode 9 by the side of minus, arise. For this reason, the sludge clearance activity of the minus side carbon electrode 9 is needed for every fixed time amount, and there is a trouble of reducing the rate of composition of fullerene C60 greatly.

[0005] In order to cancel the trouble in the fullerene automatic synthesizer unit by the above-mentioned conventional DC arc discharge, this invention is carrying out jet bleedoff of the plasma of the arc flame section according to the JxB force by the magnetic field, and controlling the amount of carbon reattachment to the carbon electrode by the side of minus, and aims at offering the new fullerene

automatic synthesizer unit to which fullerene generation mass was made to increase.

[0006]

[Means for Solving the Problem] In order to attain the above-mentioned object invention of claim 1 While being filled up with rare gas (gaseous helium, argon gas, etc.) in a vacuum chamber which is a vacuum housing Carry out opposite arrangement of the carbon electrode of a plus minus couple, and an arc flame is generated among both the above-mentioned carbon electrodes. Furthermore, a magnetic field grant means to give a magnetic field (stationary flux density) in current which flows from a plus side carbon electrode to a minus side carbon electrode, and the rectangular direction is arranged. It is characterized by making  $J \times B$  force (Lorentz force) which causes jet bleedoff of plasma in the vertical upper part to the above-mentioned arc flame give.

[0007] Moreover, invention of claim 2 is characterized by constituting a magnetic field grant means with a magnet or an electromagnet in claim 1.

[0008]

[Function] According to invention of above-mentioned claim 1, since stationary flux density exists in current and a perpendicular direction by the magnetic field, vertical top \*\* accelerates according to the  $J \times B$  force, and the electron in an arc and ion cause jet bleedoff of the plasma. On the conditions that the ambient-gas-pressure force is high, before this flow raises heat convection speed and evaporation carbon reaches a minus side carbon electrode, the carbon in mind will be pressured upwards up. Therefore, the configuration of an arc flame also serves as a form which dragged on upwards.

[0009] According to the above-mentioned operation, evaporation carbon becomes possible [ also controlling in the direction which desired acceleration and carbon flux of a heat convection besides the work which stops the reattachment to a minus side carbon electrode ], still more equivalent discharge resistance is raised, and the operation effect that lifting of carbon heating effectiveness is also expectable is acquired.

[0010] According to claim 2 of this invention, since the magnetic field grant means is depended on the magnet or the electromagnet, according to the electromagnet, accommodation of the  $J \times B$  force by accommodation of flux density can also be briefly performed by generating the  $J \times B$  force upwards to an arc flame with a brief configuration.

[0011]

[Example] Next, a drawing explains concretely about the example of the fullerene automatic synthesizer unit of the DC arc discharge concerning this invention. Drawing 1 and 2 show the 1st example of the fullerene automatic synthesizer unit 100 by the arc discharge concerning this invention.

[0012] The above-mentioned fullerene automatic synthesizer unit 100 carries out opposite arrangement of the metallic conduits 15 and 17 into the vacuum chamber 13 which is a vacuum housing made from stainless steel (for example, it is 20cm in the diameter of about 18cm, and height, and has branch pipes 13B, 13C, 13D, and 13E in the four way type within the level surface), and is making that head counter through each carbon electrodes 21 and 23 at predetermined interval in this metallic conduit 15 and 17. And the vacuum space E in the chamber 13 exhausted below to 102 Torr is made to carry out about 300 Torr restoration of the gaseous helium. The direct current voltage from the DC power supply which do not illustrate after discharge starting by contact of both the carbon electrodes 21 and 23 continues being given. Furthermore, it is constituted so that the discharge current of a direct current may always become fixed, and between discharging gaps may send out and may be controlled by the delivery control means 25 which is a motor drive to the direction of the carbon electrode 23 by the side of minus of the carbon electrode 21 by the side of plus.

[0013] As shown in drawing 2 , ahead [ of the above-mentioned fullerene automatic synthesizer unit 100 / left ] (outer wall section of the vacuum housing 13 close to branch pipe 13E) Magnet M (for example, 7x4x4cm rectangular parallelepiped ferrite magnet) is arranged, and it is given in the direction of an arrow head as stationary flux density B to which the magnetic field (the flux density of an arc portion is about 23 gauss) intersected perpendicularly between two electrodes 21 and 23 with this magnet M.

[0014] A deer is carried out, and if direct current voltage is applied and arc discharge is made to cause

between both the above-mentioned carbon electrodes 21 and 23 by the radical of discharge current  $I_d=50-100A$ , the carbon rod diameter of  $d=6mm$ , and the conditions of 30 minutes - a charging-time-value  $T_d=1$  hour, arc flame A' of drawing 5 will be generated. Since, as for above-mentioned arc flame A', the stationary flux density B exists by the magnetic field at Current J and a perpendicular direction, vertical top \*\* accelerates according to the  $J \times B$  force, and the electron in an arc and ion present the configuration which caused jet bleedoff of the plasma.

[0015] Therefore, on the conditions that the ambient-gas-pressure force is high, before this flow raises heat convection speed and reaches the carbon electrode 23 by the side of minus of evaporation carbon, the carbon in mind is pressured upwards up. Therefore, the configuration of arc flame A' also serves as a form which dragged on upwards. It acts so that a carbon-content child which the carbon electrode 21 by the side of plus is heated at this time, and it evaporates, becomes the carbon ion of plus, and is pressured upwards upwards by the heat convection within a chamber 13, and carbon atoms cause a chemical reaction in the air, and is called fullerene C60 may be generated, top-cover wall of chamber 13 13A may have much this as soot and it may adhere.

[0016] And the soot adhering to three places of side 13G and base 13F is collected in top-cover 13A of the fullerene automatic synthesizer unit 100 after discharge termination, and the weight is measured. Next, after stirring each soot well, the 1mg is extracted by the 7ml hexane, and each graph which shows below each result which measured the content of the fullerene C60 in soot by absorption spectrometry explains.

[0017] First, drawing 6 measures with those of a conventional type without a magnetic field (a) the mass  $W_{depo}$  of the carbon which carries out the reattachment to the carbon electrode 23 by the side of minus (g) with [ of this invention ] a magnetic field (b). It turns out that those with a magnetic field (b) serve as about 2 depo(es) (g), and it is decreasing 50% to about 4 depo(es) (g) of those without a magnetic field (a). Moreover, as shown in drawing 7, the comparison about deposition length  $L_{depo}$  (mm) of the carbon shaft orientations by the side of minus is also decreasing from 30depo(es) (mm) of those without a magnetic field (c) to 18depo(es) (mm) with a magnetic field (d). In addition, it is the voltage 31-35V between rods for discharge current 80A at this time, helium pressure 300Torr, a gap length of about 4mm, and charging-time-value 1 hour.

[0018] Next, drawing 8 is measuring with those with a magnetic field without a magnetic field the soot mass deposited on up 13A of a vacuum housing 13, side 13G, and pars-basilaris-ossis-occipitalis 13F. In up 13A and side 13G, the amount of soot generation is increasing by the magnetic field, it is twice [ about ] the mass of this, and, especially as for the upper part, the effect of control of carbon flux has shown up. On the other hand, the reduction mass of the plus side carbon electrode 21 at this time had a small direction with a magnetic field, and was also understood that more effective soot generating is performed.

[0019] Then, drawing 9 is comparing the absorbance of the solution which carried out the xylene extract. That is, when the content of C60 is compared from the absorbance (ABS) of C60 of  $\lambda=329nm$ , also in the upper part, the side, and which location of a pars basilaris ossis occipitalis, it turns out that the direction with a magnetic field has the high content of fullerene. The effect that especially the content in up 13A becomes about 15 % of the weight is seen. Although the equivalent resistance of discharge rises about 1% by the magnetic field and it is dependent on magnetic field intensity as others, the value is still small. The maximum gap length who does maintaining a discharge is also short by the magnetic field.

[0020] the fullerene automatic synthesizer unit 100 of this invention is not limited to the above-mentioned example, but the design change of the details configuration can be carried out -- it is natural. for example, drawing 3 and the 2nd example shown in 4 -- like -- Magnet M -- changing -- electromagnetism -- it is good also as fullerene automatic synthesizer unit 100' equipped with Coil EM with the gestalt made to fit into branch pipe 13E. Others are the same configurations as the 1st example. Also in this 2nd example, it was checked that the completely same operation effect as the fullerene automatic synthesizer unit 100 of the 1st example of the above is acquired.

[0021] that, as for the feature on the operation by this 2nd example, the direction of magnetic flux B

intersects perpendicularly thoroughly to electrodes 21 and 23, and accommodation of flux density -- electromagnetism -- since it can carry out freely by current control of Coil EM, it is also being able to perform accommodation of arc flame A', i.e., the  $J \times B$  force, free.

[0022] Each above-mentioned example is the result of manufacturing as an experimental device and being obtained from it, and when working at a actual factory, it can be made larger-scale. Moreover, although the delivery control means 25 which \*\*\*'s in the electrode wear of the plus side carbon electrode 21, and keeps an electrode spacing constant is moving the plus side carbon electrode 21, you may make it move the minus side carbon electrode 23.

[0023]

[Effect] As explained in full detail above, when being based on invention of claim 1 Since stationary flux density exists in current and a perpendicular direction by the magnetic field, vertical top \*\* accelerates according to the  $J \times B$  force, and the electron in an arc and ion cause jet bleedoff of the plasma. The ambient-gas-pressure force on high conditions Before this flow raises heat convection speed and evaporation carbon reaches a minus lateral electrode, the carbon in mind is pressured upwards up and an arc flame is made into the form which dragged on upwards. Now, the effect that the reattachment to the carbon electrode by the side of minus of evaporation carbon can be stopped is demonstrated.

[0024] Furthermore, it also becomes possible to control in the direction which desired acceleration and carbon flux of a heat convection, still more equivalent discharge resistance is raised, and many effects that lifting of carbon heating effectiveness is also expectable etc. are acquired.

[0025] and accommodation of the  $J \times B$  force according [ since the magnetic field grant means is depended on the magnet or the electromagnet when based on invention of claim 2, the  $J \times B$  force is generated upwards to an arc flame with a brief configuration, and ] to accommodation of flux density -- electromagnetism -- according to the coil, it is effective in the ability to carry out briefly.

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## DESCRIPTION OF DRAWINGS

## [Brief Description of the Drawings]

[Drawing 1] It is drawing showing the 1st example of this invention, and is the positive cross section of a fullerene automatic synthesizer unit.

[Drawing 2] It is drawing showing the 1st example of this invention, and is plane-cross-section drawing of a fullerene automatic synthesizer unit.

[Drawing 3] It is drawing showing the 2nd example of this invention, and is the positive cross section of a fullerene automatic synthesizer unit.

[Drawing 4] It is drawing showing the 2nd example of this invention, and is plane-cross-section drawing of a fullerene automatic synthesizer unit.

[Drawing 5] It is drawing showing the 1st example of this invention, and is the perspective diagram of an arc flame.

[Drawing 6] It is drawing showing the 1st example of this invention, and is comparison drawing of the amount of carbonaceous which carries out the reattachment.

[Drawing 7] It is drawing showing the 1st example of this invention, and is comparison drawing of the deposition length of carbon shaft orientations.

[Drawing 8] It is drawing showing the 1st example of this invention, and is comparison drawing of the soot mass deposited on a vacuum housing.

[Drawing 9] It is drawing showing the 1st example of this invention, and is comparison drawing of C60 content deposited on a vacuum housing.

[Drawing 10] It is plane-cross-section drawing of the fullerene automatic synthesizer unit of a conventional type.

[Drawing 11] It is the perspective diagram showing the arc flame of the fullerene automatic synthesizer unit of a conventional type.

## [Description of Notations]

13 [ ] Vacuum Housing (Vacuum Chamber)

13A [ ] a top-cover wall (upper part)

13B, 13C, 13D, 13E Branch pipe

21 [ ] Carbon Electrode by the side of Plus

23 [ ] Carbon Electrode by the side of Minus

A' Arc flame

B [ ] flux density

C60 Fullerene

EM electromagnetism -- coil (electromagnet)

M [ ] a magnet

J [ ] current

JxB Applied force

100,100' Fullerene automatic synthesizer unit

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CLAIMS

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[Claim(s)]

[Claim 1] The fullerene automatic synthesizer unit by the arc discharge carry out making the JxB force which carries out opposite arrangement of the carbon electrode of a plus minus couple, make generate an arc flame among both the above-mentioned carbon electrodes, arranges a magnetic field grant means give a magnetic field in current which flows from a plus side carbon electrode to a minus side carbon electrode further, and the rectangular direction, and causes jet bleedoff of the plasma in the vertical upper part to the above-mentioned arc flame give while filled up with rare gas in the vacuum chamber which is a vacuum housing as the feature.

[Claim 2] A fullerene automatic synthesizer unit by arc discharge characterized by constituting a magnetic field grant means with a magnet or an electromagnet in claim 1.

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[Translation done.]

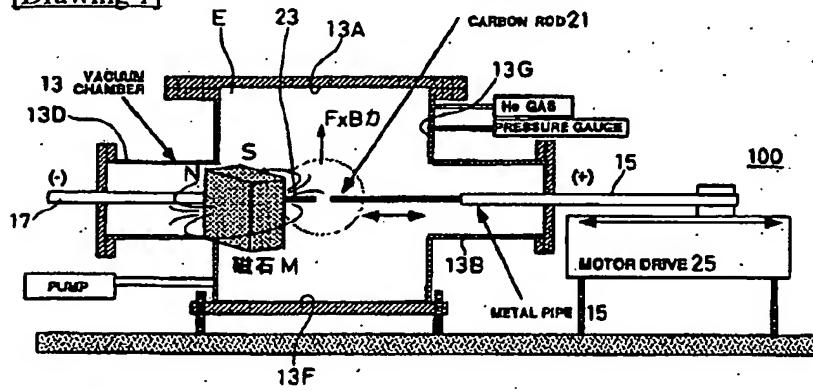
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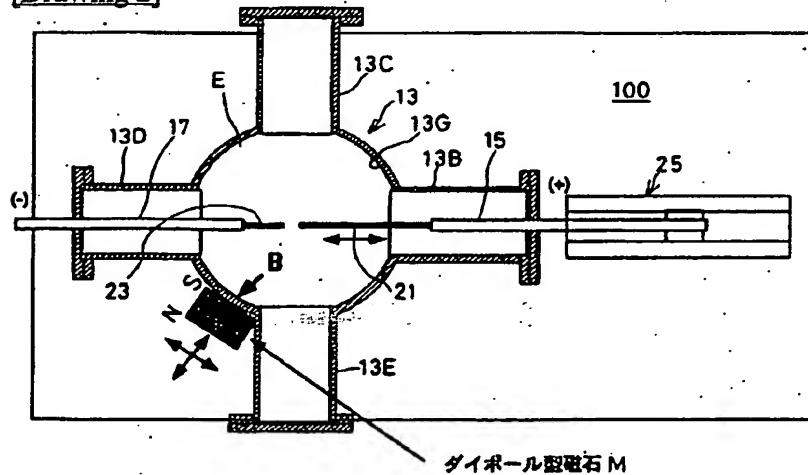
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## DRAWINGS

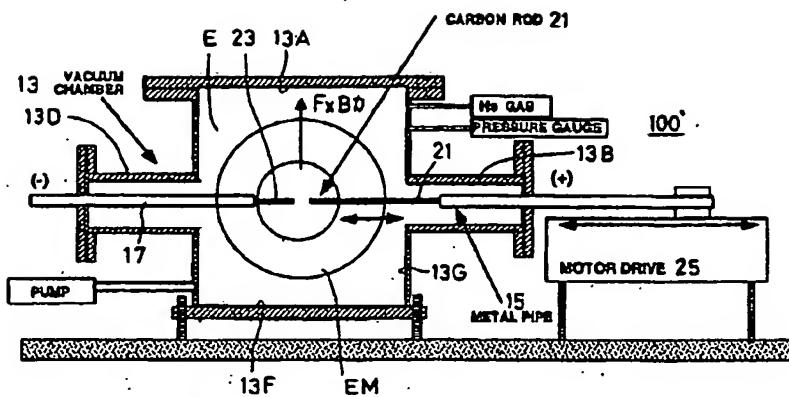
## [Drawing 1]



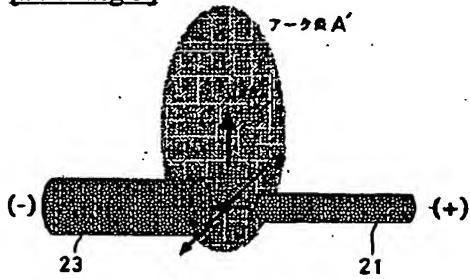
## [Drawing 2]



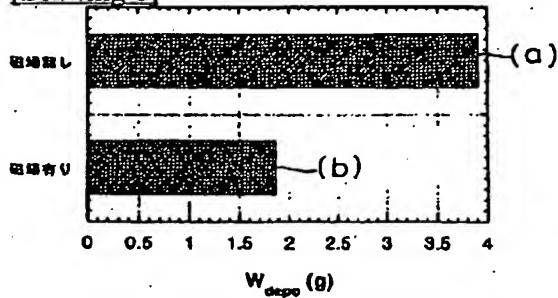
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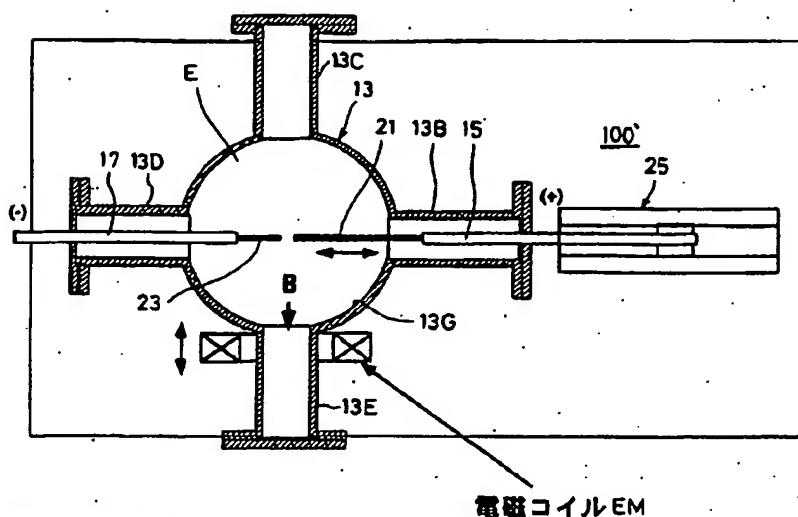
[Drawing 5]



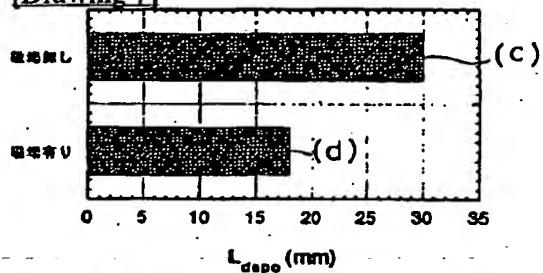
[Drawing 6]



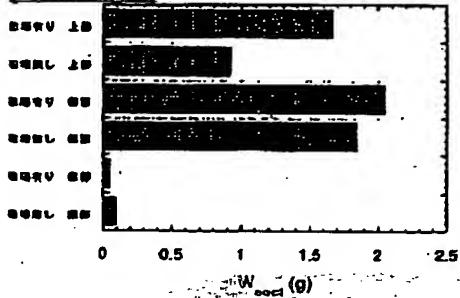
[Drawing 4]



[Drawing 7]

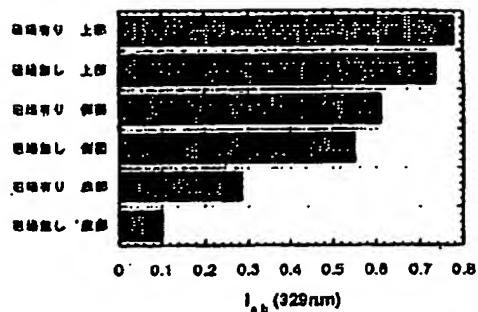


[Drawing 8]



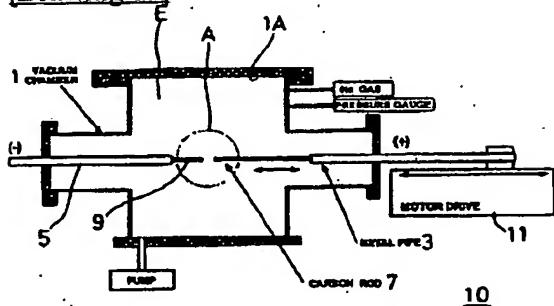
容器上部、側面、底部に堆積した  
煤質量についての比較。

[Drawing 9]

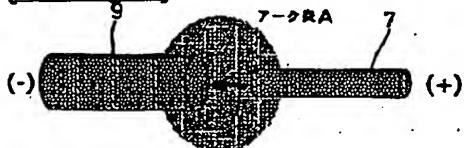


容器上部、側面、底部に堆積した  
煤のC<sub>o</sub>含有率についての比較（キ  
シレン抽出した溶液の吸光度）。

### Drawing 10



### [Drawing 11]



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CLAIMS

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[Claim(s)]

[Claim 1] The fullerene automatic synthesizer unit by the arc discharge carry out making the JxB force which carries out opposite arrangement of the carbon electrode of a plus minus pair, make generate an arc flame among both the above-mentioned carbon electrodes, arranges a magnetic field grant means give a magnetic field in the current which flows from a plus side carbon electrode to a minus side carbon electrode further, and the rectangular direction, and causes jet emission of the plasma in the perpendicular upper part to the above-mentioned arc flame give while filled up with rare gas in the vacuum chamber which is a vacuum housing as the description.

[Claim 2] The fullerene automatic synthesizer unit by the arc discharge characterized by constituting a magnetic field grant means with a magnet or an electromagnet in claim 1.

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## DETAILED DESCRIPTION

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### [Detailed Description of the Invention]

[0001]

[Industrial Application] About the fullerene automatic synthesizer unit by arc discharge, this invention reduces the carbon reattachment to the carbon electrode by the side of minus at the time of the fullerene composition by DC arc discharge, and it is improved so that more efficient fullerene composition can be performed.

[0002]

[Description of the Prior Art] The fullerene C60 contained for soot consists of a carbon molecule of a new configuration, and is used for a cell ingredient, electronics, a catalyst, etc. There is a DC arc electric discharge method as the efficient synthetic approach of the above-mentioned fullerene. This concrete fullerene synthesizer unit 10 carries out opposite arrangement of the metallic conduits 3 and 5 into the vacuum chamber 1, and makes that tip counter predetermined spacing through carbon rods 7 and 9 in this metallic conduit 3 and 5, as shown in drawing 10.

[0003] And in the condition of having made the space E in the chamber 1 made into the vacuum filling up with gaseous helium, apply direct current voltage between both the carbon electrodes 7 and 9, arc discharge is made to cause, and arc flame A of drawing 11 is generated. At this time, the carbon electrode 7 by the side of plus is heated, and it evaporates, becomes the carbon ion and carbon atom of plus, and is pressured upwards upwards by the heat convection within a chamber 1, and carbon atoms cause a chemical reaction in the air, a carbon molecule called fullerene C60 is generated, and this adheres in up wall 1A of a chamber 1 mostly as soot. The carbon electrode 7 by the side of plus carried out heating evaporation, and the carbon electrode 7 by the side of plus is sent out to the direction of the carbon electrode 9 by the side of minus by the delivery control means 11 of a motor drive so that the clearance between the carbon electrodes 9 by the side of minus may not become large.

[0004]

[Problem(s) to be Solved by the Invention] According to the fullerene synthesizer unit 10 by the above-mentioned DC arc discharge, as shown in drawing 11, on the whole, the space of two electrodes is covered by globular form "arc flame A." And the carbon ion in an arc is accelerated to the minus side. Therefore, in order that the carbon atom which carried out heating evaporation from the carbon electrode 7 by the side of plus may carry out the reattachment to the carbon electrode 9 by the side of minus positively, decline in the rate of fullerene composition and a discharge conditional control become difficult. Failures, such as difficult-izing of the continuous discharge by growth of the carbon electrode 9 by the side of minus, arise. For this reason, the sludge removal activity of the minus side carbon electrode 9 is needed for every fixed time amount, and there is a trouble of reducing the rate of composition of fullerene C60 greatly.

[0005] In order to cancel the trouble in the fullerene automatic synthesizer unit by the above-mentioned conventional DC arc discharge, this invention is carrying out jet emission of the plasma of the arc flame section according to the JxB force by the magnetic field, and controlling the amount of carbon reattachment to the carbon electrode by the side of minus, and aims at offering the new fullerene automatic synthesizer unit to which fullerene generation mass was made to increase.

[0006]

[Means for Solving the Problem] In order to attain the above-mentioned purpose invention of claim 1 While being filled up with rare gas (gaseous helium, argon gas, etc.) in the vacuum chamber which is a vacuum housing Carry out opposite arrangement of the carbon electrode of a plus minus pair, and an arc flame is generated among both the above-mentioned carbon electrodes. Furthermore, a magnetic field grant means to give a magnetic field (stationary flux density) in the current which flows from a plus side carbon electrode to a minus side carbon electrode, and the rectangular direction is arranged. It is characterized by making the JxB force (Lorentz force) which causes jet emission of the plasma in the perpendicular upper part to the above-mentioned arc flame give.

[0007] Moreover, invention of claim 2 is characterized by constituting a magnetic field grant means with a magnet or an electromagnet in claim 1.

[0008]

[Function] According to invention of above-mentioned claim 1, since stationary flux density exists in a current and a perpendicular direction by the magnetic field, perpendicular top \*\* accelerates according to the JxB force, and the electron in an arc and ion cause jet emission of the plasma. On the conditions that the ambient-gas-pressure force is high, before this flow raises a heat convection rate and evaporation carbon reaches a minus side carbon electrode, the carbon in mind will be pressured upwards up. Therefore, the configuration of an arc flame also serves as a form which dragged on upwards.

[0009] According to the above-mentioned operation, evaporation carbon becomes possible [ also controlling in the direction which desired acceleration and carbon flux of a heat convection besides the work which stops the reattachment to a minus side carbon electrode ], still more equivalent discharge resistance is raised, and the operation effectiveness that the rise of carbon heating effectiveness is also expectable is acquired.

[0010] According to claim 2 of this invention, since the magnetic field grant means is depended on the magnet or the electromagnet, according to the electromagnet, accommodation of the JxB force by accommodation of flux density can also be briefly performed by generating the JxB force upwards to an arc flame with a brief configuration.

[0011]

[Example] Next, a drawing explains concretely about the example of the fullerene automatic synthesizer unit of the DC arc discharge concerning this invention. Drawing 1 and 2 show the 1st example of the fullerene automatic synthesizer unit 100 by the arc discharge concerning this invention.

[0012] The above-mentioned fullerene automatic synthesizer unit 100 carries out opposite arrangement of the metallic conduits 15 and 17 into the vacuum chamber 13 which is a vacuum housing made from stainless steel (for example, it is 20cm in the diameter of about 18cm, and height, and has branch pipes 13B, 13C, 13D, and 13E in the four way type within a horizontal plane), and is making that tip counter through each carbon electrodes 21 and 23 at predetermined interval in this metallic conduit 15 and 17. And the vacuum space E in the chamber 13 exhausted below to 102 Torr is made to carry out about 300 Torr restoration of the gaseous helium. The direct current voltage from the DC power supply which do not illustrate after discharge starting by contact of both the carbon electrodes 21 and 23 continues being given. Furthermore, it is constituted so that the discharge current of a direct current may always become fixed, and between discharging gaps may send out and may be controlled by the delivery control means 25 which is a motor drive to the direction of the carbon electrode 23 by the side of minus of the carbon electrode 21 by the side of plus.

[0013] As shown in drawing 2 , Magnet M (for example, 7x4x4cm rectangular parallelepiped ferrite magnet) is arranged, and it is given to the method of the forward left of the above-mentioned fullerene automatic synthesizer unit 100 (outer wall section of the vacuum housing 13 close to branch pipe 13E) in the direction of an arrow head as stationary flux density B to which the magnetic field (the flux density of an arc part is about 23 gauss) intersected perpendicularly between two electrodes 21 and 23 with this magnet M.

[0014] A deer is carried out, and if direct current voltage is applied and arc discharge is made to cause between both the above-mentioned carbon electrodes 21 and 23 by the radical of discharge current  $I_d=50-100A$ , the carbon rod diameter of  $d=6mm$ , and the conditions of 30 minutes - a charging-time-value  $T_d=1$  hour, arc flame A' of drawing 5 will be generated. Since, as for above-mentioned arc flame A', the stationary flux density B exists by the magnetic field at Current J and a perpendicular direction, perpendicular top \*\* accelerates according to the JxB force, and the electron in an arc and ion present the configuration which caused jet emission of the plasma.

[0015] Therefore, on the conditions that the ambient-gas-pressure force is high, before this flow raises a heat convection rate and reaches the carbon electrode 23 by the side of minus of evaporation carbon, the carbon in mind is pressured upwards up. Therefore, the configuration of arc flame A' also serves as a form which dragged on upwards. It acts so that a carbon molecule which the carbon electrode 21 by the side of plus is heated at this time, and it evaporates, becomes the carbon ion of plus, and is pressured upwards upwards by the heat convection within a chamber 13, and carbon atoms cause a chemical reaction in the air, and is called fullerene C60 may be generated, top-cover wall of chamber 13 13A may have much this as soot and it may adhere.

[0016] And the soot adhering to three places of side-face 13G and base 13F is collected in top-cover 13A of the fullerene automatic synthesizer unit 100 after discharge termination, and the weight is measured. Next, after stirring each soot well, the 1mg is extracted by the 7ml hexane, and each graph which shows below each result which measured the content of the fullerene C60 in soot by absorption spectrometry explains.

[0017] First, drawing 6 measures with those of a conventional type without a magnetic field (a) the mass  $W_{depo}$  of the carbon which carries out the reattachment to the carbon electrode 23 by the side of minus (g) with [ of this invention ] a magnetic field (b). It turns out that those with a magnetic field (b) serve as about 2 depo(es) (g), and it is decreasing 50% to about 4 depo(es) (g) of those without a magnetic field (a). Moreover, as shown in drawing 7 , the comparison about deposition die-length  $L_{depo}$  (mm) of the carbon shaft orientations by the side of minus is also decreasing from 30depo(es) (mm) of those without a magnetic field (c) to 18depo(es) (mm) with a magnetic field (d). In addition, they

are the electrical potential differences 31-35V between rods for discharge current 80A at this time, helium pressure 300Torr, gap die length of about 4mm, and charging-time-value 1 hour.

[0018] Next, drawing 8 is measuring with those with a magnetic field without a magnetic field the soot mass deposited on up 13A of a vacuum housing 13, side-face 13G, and pars-basilaris-ossis-occipitalis 13F. In up 13A and side-face 13G, the amount of soot generation is increasing by the magnetic field, it is twice [ about ] the mass of this, and, especially as for the upper part, the effectiveness of control of carbon flux has shown up. On the other hand, the reduction mass of the plus side carbon electrode 21 at this time had a small direction with a magnetic field, and was also understood that more effective soot generating is performed.

[0019] Then, drawing 9 is comparing the absorbance of the solution which carried out the xylene extract. That is, when the content of C60 is compared from the absorbance (ABS) of C60 of lambda= 329nm, also in the upper part, a side face, and which location of a pars basilaris ossis occipitalis, it turns out that the direction with a magnetic field has the high content of fullerene. The effectiveness that especially the content in up 13A becomes about 15 % of the weight is seen. Although the equivalent resistance of discharge rises about 1% by the magnetic field and it is dependent on magnetic field strength as others, the value is still small. The maximum gap length who does maintaining a discharge is also short by the magnetic field.

[0020] the fullerene automatic synthesizer unit 100 of this invention is not limited to the above-mentioned example, but the design change of the detail configuration can be carried out -- it is natural. for example, drawing 3 and the 2nd example shown in 4 -- like -- Magnet M -- changing -- electromagnetism -- it is good also as fullerene automatic synthesizer unit 100' equipped with Coil EM with the gestalt which carried out fitting to branch pipe 13E. Others are the same configurations as the 1st example. Also in this 2nd example, it was checked that the completely same operation effectiveness as the fullerene automatic synthesizer unit 100 of the 1st example of the above is acquired.

[0021] that, as for the description on the operation by this 2nd example, the direction of magnetic flux B intersects perpendicularly completely to electrodes 21 and 23, and accommodation of flux density -- electromagnetism -- since it can carry out freely by current control of Coil EM, it is also being able to perform accommodation of arc flame A', i.e., the FxB force, free.

[0022] Each above-mentioned example is the result of manufacturing as an experimental device and being obtained from it, and when working at actual works, it can be made larger-scale. Moreover, although the delivery control means 25 which \*\*\*'s in electrode consumption of the plus side carbon electrode 21, and keeps an electrode spacing constant is moving the plus side carbon electrode 21, you may make it move the minus side carbon electrode 23.

[0023]

[Effect] As explained in full detail above, when being based on invention of claim 1 Since stationary flux density exists in a current and a perpendicular direction by the magnetic field, perpendicular top \*\* accelerates according to the JxB force, and the electron in an arc and ion cause jet emission of the plasma. The ambient-gas-pressure force on high conditions Before this flow raises a heat convection rate and evaporation carbon reaches a minus lateral electrode, the carbon in mind is pressured upwards up and an arc flame is made into the form which dragged on upwards. Now, the effectiveness that the reattachment to the carbon electrode by the side of minus of evaporation carbon can be stopped is demonstrated.

[0024] Furthermore, it also becomes possible to control in the direction which desired acceleration and carbon flux of a heat convection, still more equivalent discharge resistance is raised, and much effectiveness that the rise of carbon heating effectiveness is also expectable etc. is acquired.

[0025] and accommodation of the JxB force according [ since the magnetic field grant means is depended on the magnet or the electromagnet when based on invention of claim 2, the JxB force is generated upwards to an arc flame with a brief configuration, and ] to accommodation of flux density -- electromagnetism -- according to the coil, it is effective in the ability to carry out briefly.

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[Translation done.]

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the 1st example of this invention, and is the forward sectional view of a fullerene automatic synthesizer unit.

[Drawing 2] It is drawing showing the 1st example of this invention, and is the plane section Fig. of a fullerene automatic synthesizer unit.

[Drawing 3] It is drawing showing the 2nd example of this invention, and is the forward sectional view of a fullerene automatic synthesizer unit.

[Drawing 4] It is drawing showing the 2nd example of this invention, and is the plane section Fig. of a fullerene automatic synthesizer unit.

[Drawing 5] It is drawing showing the 1st example of this invention, and is the perspective view of an arc flame.

[Drawing 6] It is drawing showing the 1st example of this invention, and is the comparison Fig. of the amount of carbonaceous which carries out the reattachment.

[Drawing 7] It is drawing showing the 1st example of this invention, and is the comparison Fig. of the deposition die length of carbon shaft orientations.

[Drawing 8] It is drawing showing the 1st example of this invention, and is the comparison Fig. of the soot mass deposited on a vacuum housing.

[Drawing 9] It is drawing showing the 1st example of this invention, and is the comparison Fig. of C60 content deposited on a vacuum housing.

[Drawing 10] It is the plane section Fig. of the fullerene automatic synthesizer unit of a conventional type.

[Drawing 11] It is the perspective view showing the arc flame of the fullerene automatic synthesizer unit of a conventional type.

[Description of Notations]

13 [ ] Vacuum Housing (Vacuum Chamber)

13A [ ] a top-cover wall (upper part)

13B, 13C, 13D, 13E Branch pipe

21 [ ] Carbon Electrode by the side of Plus

23 [ ] Carbon Electrode by the side of Minus

A' Arc flame

B [ ] flux density

C60 Fullerene

EM electromagnetism -- coil (electromagnet)

M [ ] a magnet

J [ ] a current

JxB Applied force

100,100' Fullerene automatic synthesizer unit

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[Translation done.]

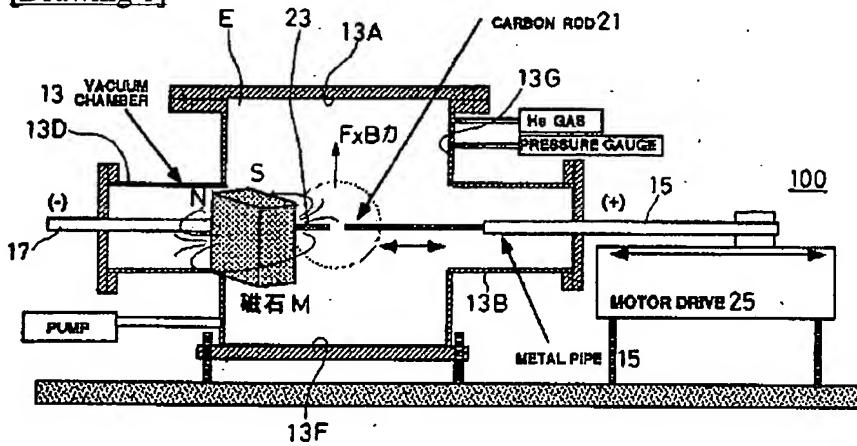
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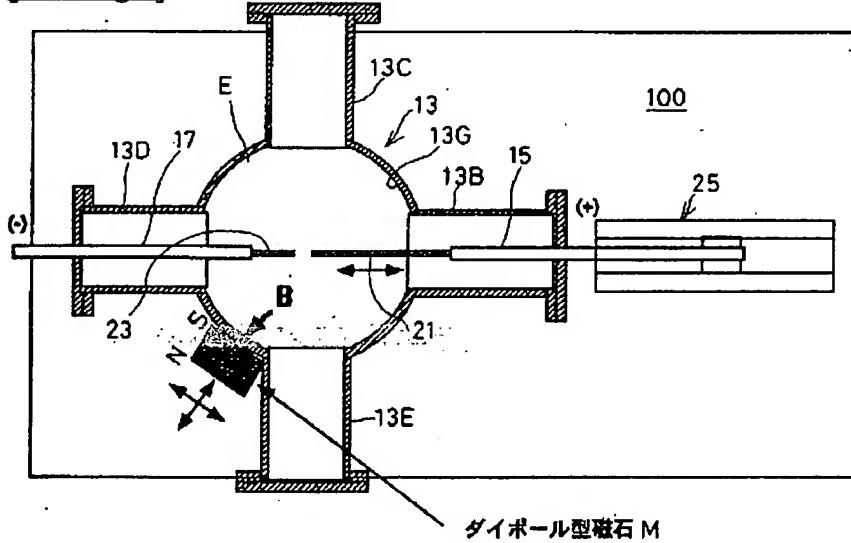
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DRAWINGS

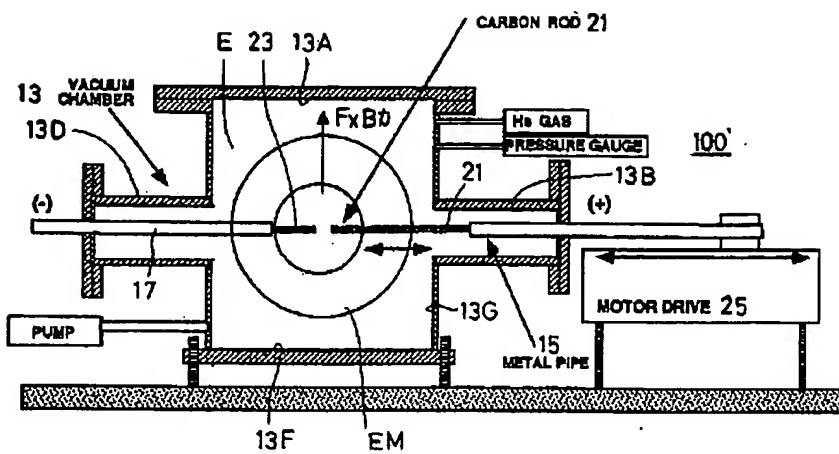
[Drawing 1]



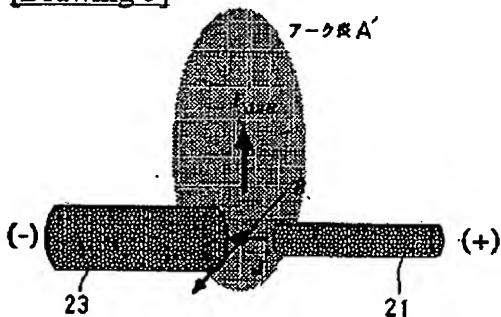
[Drawing 2]



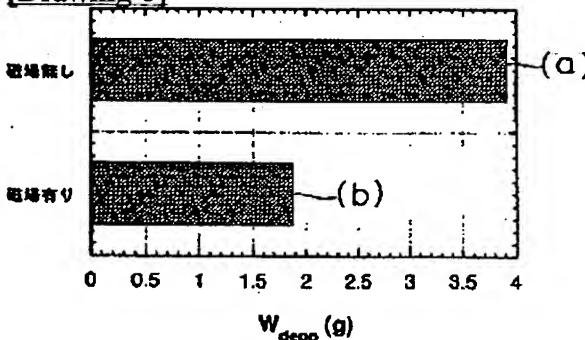
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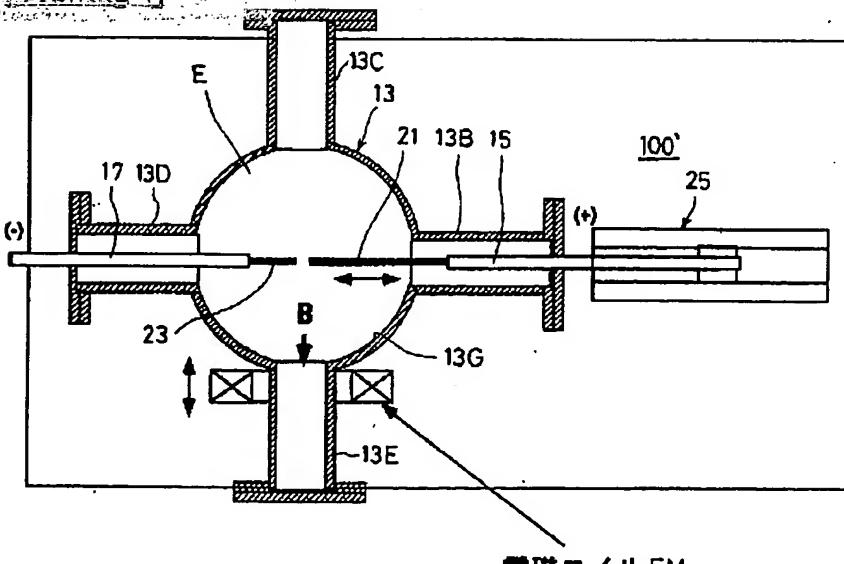
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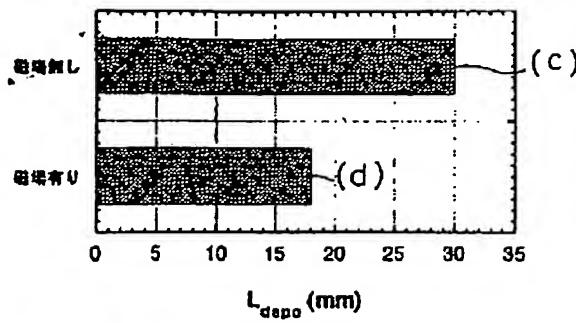
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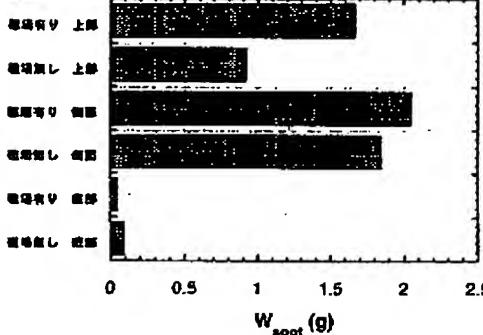
[Drawing 4]



[Drawing 7]

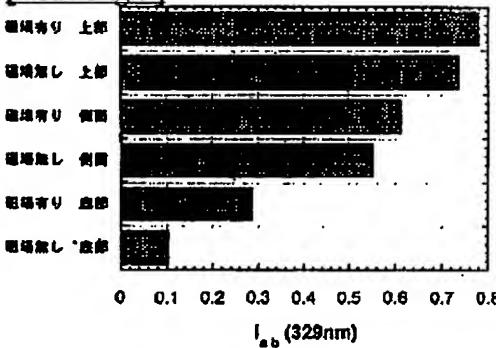


[Drawing 8]



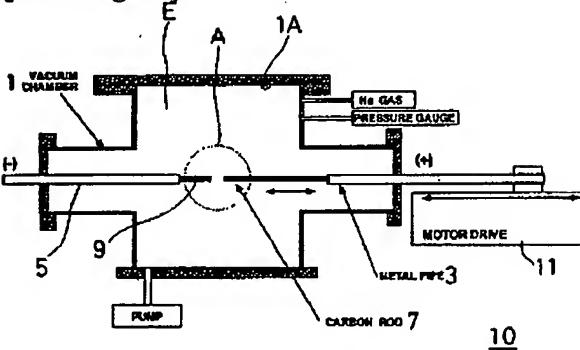
容器上部、側面、底部に堆積した  
煤質量についての比較。

[Drawing 9]

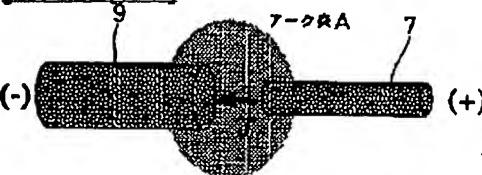


容器上部、側面、底部に堆積した  
煤のC<sub>60</sub>含有率についての比較 (キ  
シレン抽出した溶液の吸光度)。

[Drawing 10]



[Drawing 11]



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[Translation done.]